CHAPTER 9.—DUST RESPIRATORS IN MINES AND TUNNELS

By Fred N. Kissell, Ph.D.,[84] and William A. Hoffman[85]

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In many cases, engineering controls are not adequate to achieve satisfactory dust levels, so respirators must be used. This chapter explains the Federal regulations governing the use of dust respirators in mines and tunnels and describes the most common dust respirators used. Filter materials and filter efficiencies for respirators are discussed. This chapter also gives some guidelines for respirator use and recommends sources for more dust respirator information. Respirator effectiveness in reducing dust exposure usually exceeds the effectiveness of most engineering control methods.

RESPIRATOR REGULATIONS

Different regulations govern respirator use in coal mines, metal/nonmetal mines, and tunnels under construction.

Coal mines under Mine Safety and Health Administration (MSHA) jurisdiction. Coal mine operators are required to meet dust standards using only engineering control methods. Typical engineering control methods include ventilation and water sprays. Respirators are not regarded as an engineering control method, so respirators cannot be used in lieu of engineering controls.

[84]Research physical scientist, Pittsburgh Research Laboratory, National Institute for Occupational Safety and Health, Pittsburgh, PA.

[85]Physical scientist, National Personal Protective Technology Laboratory, National Institute for Occupational Safety and Health, Pittsburgh, PA.

However, if dust levels exceed the 2.0 mg/m^3 coal dust standard,[86] approved respirators must be made available[87] to workers [30 CFR[88] 70.300] while new engineering controls are being instituted. Respirators must also be provided to workers exposed to high-inhalation hazards for short periods.[89]

Coal mine operators may also choose to establish a respiratory protection program, as set forth by the American National Standards Institute (ANSI Z-88.2-1969)[90] [ANSI 1969; 30 CFR 72.710]. Such programs must include written procedures containing provisions for training, fit-testing, maintenance, recordkeeping, and a requirement that users be clean-shaven [MSHA 1995]. According to MSHA, if there is a respiratory protection program, the existence of such a program may form the basis for further extensions of abatement times or help to create an argument that a violation is less serious. However, a program will not prevent the issuance of citations for exceeding the dust standard.

Metal/nonmetal mines under MSHA jurisdiction. MSHA metal/nonmetal regulations are somewhat less restrictive than the coal regulations. Removal of dust by engineering controls remains the required method. However, when accepted engineering control measures have not been developed or when the dust standard is exceeded on an occasional basis, respiratory equipment may be used without a citation being issued, provided that all of the following requirements are met:

1. The respirators used must be approved by NIOSH under 42 CFR 84.
2. A respiratory protection program, as set forth by ANSI Z-88.2-1969 [ANSI 1969], is or has been instituted [30 CFR 56.5005; 30 CFR 57.5005].
3. When respiratory protection is used in atmospheres immediately dangerous to life, a second worker with backup equipment and rescue capability is required.

Tunnels under Occupational Safety and Health Administration (OSHA) jurisdiction. Under OSHA, engineering controls are also the required method of dealing with dust. However, OSHA regulations permit respirators to be used in place of engineering controls if engineering controls are not feasible or while engineering controls are being instituted [29 CFR 1910.134(a)(1)].

If respirators are used, a respiratory program is required to ensure that respirators are used properly and employees are protected [29 CFR 1910.134(c)]. This program has several required elements. The major ones are [OSHA 1998a]:

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[86]If the coal contains silica, the standard is lowered according to a formula prescribed by MSHA.

[87]Operators must also maintain a supply of respirators consistent with this need.

[88]*Code of Federal Regulations.* See CFR in references.

[89]In the MSHA program policy manual, the term "short periods" is interpreted as the time required to drill three or four holes for trolley hangers, to drill shot holes in a roof fall, etc.

[90]The current version is ANZI-88.2-1992, but the MSHA regulations are based on the 1969 version.

1. A worksite-specific document explaining the respiratory protection program.
2. Selection of a designated administrator who is qualified to oversee the program.
3. A medical evaluation to determine the employee's ability to use a respirator.
4. Fit-testing of respirators to ensure minimal leakage.
5. Training in respirator use and care, particularly "user seal checks" by the wearer.

The OSHA "Voluntary Use" Program. For workplaces that are in compliance with dust standards, employers can permit their workers to wear air-purifying respirators under a "voluntary use" arrangement if they choose to do so [29 CFR 1910.134(c)(2)]. In this case, a program document, a medical evaluation, and respirator maintenance are all still required. No training is required [OSHA 1998b], but employees must be provided with advisory information [29 CFR 1910.134 appendix D]. Fit-testing is not necessary [OSHA 1998c], and less experience is required of the program administrator.

Some of the voluntary use program requirements (program document, medical evaluation, and respirator maintenance) do not apply to workers who voluntarily use dust masks [OSHA 1998b]. However, users of dust masks must be provided with the advisory information in 29 CFR 1910.134 appendix D.

TYPES OF RESPIRATORS USED IN MINES AND TUNNELS

Mine operators usually choose half-mask respirators, dust masks, or air helmets equipped with particulate filters.[91] Half-mask respirators and dust masks are convenient for confined surroundings. Air helmets are suitable when more space is available, such as at longwall faces in high coal.

Half-mask replaceable-filter respirators. Half-mask replaceable-filter respirators (figure 9-1), also known as reusable half-masks, consist of a filter-holding unit, fabricated from molded plastic or rubber, that contains intake and exhaust valves. Soft rubber is used to form a facepiece around the filter-holding unit, which forms a seal against the wearer's face. This seal prevents dust-laden air from bypassing the filter as the user inhales. *If* the facepiece seal is leak-tight, the respirator should remove 90% or more of the respirable dust.

[91] All must be NIOSH-approved under the requirements of 42 CFR 84. The half-mask replaceable filter respirators and the dust masks are classified as "air-purifying respirators" (APRs); the air helmet is classified as a "powered air-purifying respirator" (PAPR) because it is powered by a small fan.

Although the half-mask replaceable-filter respirators do a reasonable job of dust removal when the facepiece seal is leak-tight, the seal can occasionally cause skin irritation. These respirators also interfere with conversation and may interfere with eyeglasses or goggles.

Figure 9-1.—Half-mask replaceable-filter respirator.

Many different types of filter materials are available for half-mask respirators. Some filter materials are degraded by oil mist. The replaceable filter cartridges are designated according to their level of oil resistance, as follows:

Type **N** filters are **N**ot resistant to oil;
Type **R** filters are oil-**R**esistant up to one shift; and
Type **P** filters are oil-**P**roof.

For coal dust or for mineral dusts such as silica, any of these types of filters is satisfactory. Some mines have oil mist sources; the most common are percussion drills. These mines should use type R or type P filters.

The dust (or mist) collection efficiency of filter materials also varies; the efficiency is specified along with the oil resistance. Filter cartridges are available in three efficiency levels: 95%, 99%, and 99.97%, designated as 95, 99, and 100. For example, an N95 filter is 95% efficient; an N100 filter is 99.97% efficient.

Actually, filter efficiencies for respirable dust are much higher than the specified filter efficiency. This is because the specified filter efficiencies are measured using the size of particles that are most likely to get through the filters—about 0.3 μm in diameter. Most respirable dust is larger than this, which makes it easier to filter. Thus, a filter that is 95% efficient for 0.3 μm particles will exhibit a much greater efficiency for respirable dust.

The most commonly purchased filter types are N95s and P100s. Type 95 filters usually have a lower cost and lower breathing resistance than type 100 filters.

While filter efficiencies may be very high, it does not follow that workers are protected with the same degree of efficiency.[92] For instance, the rule-of-thumb efficiency for half-mask respirators is 90% for respirators that give a good fit. This is lower than the filter efficiency because some leakage at the seal against the wearer's face usually occurs. For example, during one respirator

[92]Keep in mind that efficiency numbers quoted in respirator catalogs only refer to filter efficiency.

evaluation program [Cole 1984], half-mask respirators were tested on four longwall sections. The dust exposure of workers was reduced by 92%.

Figure 9-2.—Dust mask, also called a filtering facepiece.

Dust masks. Dust masks (also known as filtering facepiece respirators) (figure 9-2) have a lighter and simpler design than half-mask respirators. The entire mask is fabricated from filter material and covers the mouth and nose, similar to a surgical mask. Dust masks offer some advantages compared to the replaceable-filter respirators. In particular, they are more comfortable and require no maintenance. However, dust masks usually do not form as tight a seal against the wearer's face as half-masks with soft rubber seals, which allows more leakage. As a result, they are often much less effective than half-masks.

Dust masks are certified by NIOSH under the 42 CFR 84 respirator certification tests. These standards only require a test of the filter material and do not assess how well the mask seals against the wearer's face. As a result, this certification is no guarantee that the mask will perform well. In a recent study of dust masks [CDC 1998], the average dust reduction was only 67%.[93]

In the mining industry, half-mask respirators are used far more than dust masks because their dust reduction efficiencies are much higher.

Air helmets. The air helmet (figure 9-3) is a redesigned hard hat equipped with a battery-powered fan, filtering system, and face visor, thus providing protection for the head, lungs, and

[93]The study got much better results after fit-testing was performed, and individuals who failed the fit-test were dropped from the study. The authors of the study then concluded that fit-testing was necessary if dust masks were to be used. Nevertheless, any organization that goes to the trouble and expense of fit-testing its workers is better off with half-mask replaceable-filter respirators.

The 67% figure for dust masks is low compared to other types of respirators, but it is still better than the dust reduction produced by many engineering controls.

eyes within one unit. Other advantages are a lack of breathing resistance, the ability to accommodate facial hair, and no fit-testing requirement for their use.

Figure 9-3.—Air helmet.

Although air helmets are slightly larger and heavier than conventional hard hats (they typically weigh about 3 lb), wearer acceptance has been favorable in high coal seams (particularly at longwalls) and in many hard-rock mines.

A small fan is mounted in the rear of the helmet to draw dust-laden air through a filtering system. The filtered air is directed behind a full-face visor and over the wearer's face. Exhaled air and excess clean air exit the helmet at the bottom of the face visor. Face seals are provided along both sides of the visor to limit contamination from outside air. The fan is externally powered by a rechargeable battery worn on the miner's belt. Filter life varies from one to eight shifts depending on the dust level at the worksite [Parobeck et al. 1989].

The effectiveness of the air helmet depends in part on the mine air velocity outside of the helmet and the direction of air impact on the helmet [Cecala et al. 1981], because high air velocities push dust particles past the face seals. For example, at a longwall face with an air velocity of less than 400 ft/min, air helmets reduced respirable dust by an average of 84%. However, at another longwall with an air velocity of 1,200 ft/min, the air helmet was not as effective; dust reduction averaged 49%. In both cases, the sampling included some periods when the face visor was raised. Raising the visor reduces the helmet's effectiveness.

RESPIRATORS FOR DIESEL EXHAUST

Diesel exhaust, both the particulate and the organic vapors, have become more of a concern in recent years. Half-mask respirators will filter both the diesel particulate and the organic vapors when equipped with the proper cartridge or cartridge combination. A common cartridge designnation is Organic Vapor/P100, or OV/P100. Half-mask respirators will not protect the eyes from irritating fumes. Eye-irritating fumes are best handled by installing a catalytic converter on the engine [Schnakenberg and Bugarski 2002].

DONNING, SEAL CHECKING, AND MAINTENANCE

When putting on the respirator, the wearer should follow the manufacturer's instructions. Comfort is as important as a tight seal. The wearer may need to try different size respirators or

respirators from different manufacturers before finding one that conforms to his or her facial structure.

Once a respirator is donned, a seal check is necessary to ensure there are no leaks that would degrade the respirator's effectiveness. Either the positive- or negative-pressure check described below[94] or the respirator manufacturer's recommended user seal check method must be performed.

Seal checking is important for a respirator to be effective.

Positive-pressure seal check. To perform a positive-pressure seal check, the wearer closes off the exhalation valve and blows gently into the facepiece. The face fit is satisfactory if a slight positive pressure can be built up inside the facepiece without any evidence of outward leakage of air at the seal. For most respirators, this method of leak testing requires the wearer to first remove the exhalation valve cover before closing off the exhalation valve.

Negative-pressure seal check. To perform a negative-pressure seal check, the wearer closes off the inlet opening of the canister or cartridge by covering it with the palm of the hand or by replacing the filter seal. Next, the wearer inhales gently so that the facepiece collapses slightly, then the breath is held for 10 sec. If the facepiece remains in its slightly collapsed condition and no inward leakage of air is detected, the tightness of the respirator is satisfactory. However, the inlet opening of some filter cartridges cannot be sealed with the palm of the hand. In such cases, the test can be done by covering the inlet opening of the cartridge with a thin latex glove.

During the seal check, the respirator wearer should pay the most attention to the region around his or her nose because it is the most likely place for leaks. Also, there should be no interference with eyeglasses.

Respirator maintenance. Basic respirator maintenance is simple. The wearer should check to ensure that the filter cartridges are undamaged, the inhalation and exhalation valves are in working order, no straps are slipping or broken, there are no tears or deformities in the facepiece, and the respirator is reasonably clean.

FILTER SERVICE LIFE

Regular replacement of filters is an important part of respirator use [NIOSH 1997]. Normally, filters should be replaced when breathing resistance increases. Another approach is to replace filters when the filter loading reaches 200 mg of dust. Using this filter loading approach, if a

[94]From OSHA regulations at 29 CFR 1910.134 appendix B-1: User Seal Check Procedures.

worker breathes 10 m^3 per shift and the dust concentration is 5 mg/m^3, the loading is 50 mg per shift, or 25 mg per filter if there are two filters. The two filters would then be good for eight shifts.
If oil mist is present, N-series filters should not be used. R-series filters should be used for one shift, and P-series filters should be changed in accordance with the manufacturer's recommendations.

RESPIRATOR RESOURCES

Many organizations on the Internet are good sources of information on respirators and respiratory protection programs.

NIOSH has respirator publications at www.cdc.gov/niosh/respinfo.html. The two most useful are the *NIOSH Guide to the Selection and Use of Particulate Respirators Certified Under 42 CFR 84* [NIOSH 1996] at www.cdc.gov/niosh/userguid.html and the *NIOSH Guide to Industrial Respiratory Protection* [Bollinger and Schutz 1987] at www.cdc.gov/niosh/87-116.html.

OSHA has a downloadable *Small Entity Compliance Guide for the Revised Respiratory Protection Standard* at www.osha.gov/Publications/secgrev-current.pdf. Also, OSHA has a series of photographs that can be used for training at www.osha.gov/RespiratorOutreach/Powerpoint/Html/RespStd/sld001.htm.

The International Safety Equipment Association provides a useful buyer's guide at www.safetyequipment.org. The International Society for Respiratory Protection (www.isrp.com.au) provides information on respiratory protection. The society publishes a quarterly journal and convenes periodic conferences.

In addition to publications on the Internet, the American Conference of Governmental Industrial Hygienists (www.acgih.org) sells a *Respiratory Protection Program and Record Keeping Kit* as publication No. 9278CB. The American Industrial Hygiene Association (www.aiha.org) sells *Respiratory Protection: A Manual and Guideline* as stock No. 439-PC-01.

Respirator fit-testing and other respirator-related services are readily available for hire.

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